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Association of Generalized Joint Hypermobility and Occurrence of Musculoskeletal Injury in Physical and Occupational Therapy Students

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ASSOCIATION OF GENERALIZED JOINT HYPERMOBILITY AND OCCURRENCE OF MUSCULOSKELETAL INJURY IN PHYSICAL AND OCCUPATIONAL THERAPY STUDENTS

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PERMISSION

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ABSTRACT

Background: A prior research study showed that the prevalence of hypermobility was higher among Physical and Occupational Therapy students as compared to the general population. The literature shows that certain injury rates are higher among those who are hypermobile. This has led to the question of whether or not hypermobility is directly related to injury and recurrence of injury.

Purpose: The purpose of this study was to assess Physical Therapy (PT) and Occupational Therapy (OT) students for hypermobility as well as survey previous injury history. This study analyzed the prevalence of hypermobility with types of injuries in order to determine if a relationship exists.

Methods: Eighty-six subjects (24 male, 62 female) were assessed for hypermobility using the nine point Beighton Scale of Hypermobility. A score of four or higher out of nine indicated the presence of joint hypermobility. Participants filled out a survey regarding current activity level, previous and current athletic participation, injury history regarding type and mechanism of injury.

Results: The prevalence of hypermobility among PT and OT students was found to be 39.5%, a rate five times greater than the general population. Reported injuries were grouped into the following classifications prior to statistical analysis: sprains, ligament rupture, strain/contusion, fracture, and dislocation. Non-hypermobile participants were more likely to have experienced a strain type injury ($\chi^2(1, N=86) = 5.059$, $p=0.024$). No other statistically significant results were found, although fracture rates showed a trend of occurring more frequently in non-hypermobile participants ($p=0.167$).

Conclusion: The prevalence of joint hypermobility is higher among Physical and Occupational Therapy students than the general population. Injury rates are high among both PT and OT populations, with strains occurring more frequently in non-hypermobile subjects. In the future, increased sample size, as well as inclusion of the general student population may lead to a greater significance in research results. Further research is needed to determine the extent of such correlation.

Keywords: hypermobility; injury; prevalence; occurrence; recurrence; physical therapy; occupational therapy

CHAPTER I

INTRODUCTION

Scope of Study

The focus of this study was to determine the prevalence of hypermobility and associated injury rates among physical therapy (PT) and occupational therapy (OT) students at the University of North Dakota. This study expanded upon two previous studies by Hestekin[1] and Selinger, Newman, and Jensen-Bak[2]. The initial study by Hestekin[1] showed that 21% of physical therapy students exhibited signs of systematic hypermobility, nearly 3 times that of the general population. The follow up study by Selinger et al[2] attempted to determine if there was a relationship between hypermobility and type of injuries sustained by students in PT and OT professional education programs. The reported hypermobility of the population was 32.6%, with dislocations being the most frequent type of injury associated with hypermobility status. This study replicated the study by Selinger et al[2] but also included the re-occurrence rates of injuries. University of North Dakota PT and OT students participated in this study to assess the hypermobility rate in this population.

Therapists are more prone to work injuries due to the physical demands of the job according to Bork et al[3]. The study found the anatomical area that was most commonly affected in PTs was the low back with 45% of the population having symptoms, second were wrists and hands with 29.6% of the population. The presence of hypermobility, in addition to the demands of the profession, may have the potential to further increase injury rates among therapists. Once hypermobility is recognized, preventative measures should be taken to ensure that professionals can continue to work in their field safely and successfully.

Problem Statement

This study focused on the prevalence of hypermobility and how it correlates to types of musculoskeletal injuries among PT and OT students. Inconsistencies have been noted in the literature regarding the types of injuries that are more likely to occur as a result of the increased laxity in the joints. Little to no research has been conducted regarding re-occurrence rates associated with hypermobility status. Therefore, it was important to develop consistent information regarding this issue.

Purpose of Study

The purpose of this study was to assess PT and OT students for hypermobility. This study was designed to determine if there is a difference in the type and frequency of injuries between hypermobile and non-hypermobile PT and OT students. Hypermobility status was determined by scoring 4 or more on the Beighton Hypermobility Scale. The scores were compared to the type and frequency of previous injuries to see if there was a relationship. There was minimal correlation between soft tissue injury rate and systemic hypermobility in this population. The clinical application of this study was to increase awareness of hypermoblity and its associated risks. If hypermobility is determined, measures can be taken to prevent work related injuries by understanding the associated risks and practicing proper body mechanics.

Significance of the Study

Previous research studies have indicated significantly higher prevalence of hypermobility in PT and OT students using the Beighton Hypermobility Scale[1,2]. If PT and OT students tend to have a higher prevalence of systemic hypermobility, this may lead to increased risk of soft tissue injuries. Individuals in these professions need to be aware of their hypermobility and how to protect themselves from injury by using proper body mechanics and other joint protection techniques.

Research Question

What is the hypermobility rate among PT and OT students? Do PT and OT students who display systemic hypermobility have a greater incidence of soft tissue injuries as compared to non-hypermobile PT and OT students?

Hypotheses and Alternative Hypotheses

Null Hypothesis: There is no significant difference in prevalence of hypermobility among PT and OT students as compared to the general population.

Alternative Hypothesis: There is a significant difference in prevalence of hypermobility among PT and OT students as compared to the general population. Physical and Occupational Therapy students are more hypermobile.

Null Hypothesis: There is no significant relationship in the incidence of a soft tissue injury or injury types among PT and OT students who are hypermobile as compared with those who are not hypermobile.

Alternative Hypothesis: There is a significant relationship in the incidence of a soft tissue injury or injury types among PT and OT students who are hypermobile as compared with those who are not hypermobile.

Null Hypothesis: There is no significant difference in the recurrence rate of injuries among PT and OT students who are hypermobile as compared with those who are not hypermobile.

Alternative hypothesis: There is a significant difference in the recurrence rate of injuries among PT and OT students who are hypermobile as compared with those who are not hypermobile.

CHAPTER II

LITERATURE REVIEW

People have been intrigued with how hypermobility can affect individuals for thousands of years dating back to the time of Hippocrates according to Grahame[4]. In the 4th century BC, Hippocrates described the Scythians as being, "so loose-limbed that they were unable to draw a bow-string or hurl a javelin."[4 (p.692)] Joint hypermobility was recognized as being clinically significant in the 19th century. Tschernogonas determined that there was an association between characteristics of connective tissue including "hyperextensibility of the skin and the hypermobility and luxation of the joints"[4 (p.32-33)] in individuals with Ehlers-Danlos syndrome.

In 1967, Kirk et al[5] researched the association between joint laxity and musculoskeletal complaints, which they called hypermobility syndrome, however, the cause of this hypermobility was not known. Presently, hypermobility is diagnosed when an individual has range of motion (ROM) in synovial joints that is beyond normal limits[6]. It is important to note that individuals with genetic diseases that affect joint hypermobility such as Ehlers-Danlos Syndrome, Osteogenesis Imperfecta, and Marfan Syndrome are not included in this category of hypermobility syndrome.

Hypermobility syndrome is defined as generalized joint laxity with an association of musculoskeletal symptoms, "where the joints are unduly lax and the range of motion is in excess of the accepted normal in most of the joints examined" according to Kirk et al[5]. A variety of terms are used interchangeably to describe hypermobility syndrome.

According to Russek[7], there are currently four names commonly used: hypermobility syndrome (HMS), joint hypermobility syndrome, hypermobile joint syndrome, and benign hypermobile joint syndrome. In this study the term hypermobility syndrome (HMS) is used to consistently refer to individuals who have widespread hypermobility of the joints.

The prevalence of HMS in the adult population was found to be 7.6% by Díaz et al[8] with a higher prevalence of HMS in females as compared to males[9]. The prevalence in adolescents was found to be 11.7% by Seckin et al[10]. Hypermobility Syndrome is more prevalent in Asians Indians and Africans than English Caucasians[9, 11]. The difference between races alludes to the fact that genetics may be an important factor in the probability of being hypermobile. Simpson[12] found that there is a strong genetic component with an autosomal dominant pattern with the identification of HMS in as many as 50% of first degree relative cases. Sahin et al[13] found that variations or mutations of genes that code elastin, collagen, fibrillin, and tenascin lead to the biological component of HMS.

Connective tissue is primarily composed of collagen, which gives tendons, ligaments, and joint capsules their ability to stabilize joints. The most prevalent collagen in the human body is Type I, which is found in all ligaments, tendons, joint capsules, skin, demineralized bone, and nerve receptors. It appears that individuals with HMS have a decreased amount of Type I collagen when compared to the non-hypermobile population. In a study by Child[14], it was found that individuals with HMS have an abnormally small proportion of the stronger Type I collagen and an increase in the more extensible Type III collagen. Type III collagen is typically found in the vascular system, skin, and lungs. The increased proportion of Type III to Type I collagen may likely be the reason for the increased tissue extensibility in individuals with HMS.

Hypermobility is not always the result of genetic and biological changes but can be acquired through external means such as excessive stresses placed on the body; this is known as adaptive hypermobility. An example of adaptive hypermobility is when individuals such as dancers and gymnasts may acquire hypermobility through years of training and stretching. A key feature of adaptive hypermobility is the absence of impact on the physiological composition of the connective tissue in the body. However, it is impossible to differentiate between adaptive and genetic hypermobility through gross physical evaluations, such as the Beighton Scale. Whether the result of hypermobility be due to genetics or lifestyle, individuals who are hypermobile are more highly associated with injury than non-hypermobile counterparts.

Diagnosis of an individual with HMS, whether it is of systemic and/or adaptive origin, can occur at any age. Symptoms can vary, but common characteristics include increased laxity in multiple joints and joint pain. Hypermobility can be found in various joints and can be present unilaterally or bilaterally. The most common joints that are found to be hypermobile are the knee and ankle[12]. Additional joints that are commonly hypermobile include joints of the fingers and hands[6]. However, with HMS, any other joint could be hypermobile as well.

Individuals with HMS have a higher frequency of musculoligamentous lesions than those with normal joint laxity according to Díaz et al[8]. Beighton et al[9] found a positive correlation between joint laxity and musculoskeletal symptoms as well as between joint laxity and arthralgic complaints. Individuals with HMS may experience a variety of intra-articular symptoms including ligament rupture, tendon rupture, hip dysplasia, temporomandibular joint dysfunction, scoliosis, pes planus, increased lordosis, and genu valgum[15]. These intra-articular symptoms may be related to a lack of proprioception surrounding the joint.

Proprioception refers to the sensation of position and movement of joints under dynamic conditions. An individual's ability to maintain joint stability is highly connected with joint proprioception. Hypermobility has been linked to a significant decrease in proprioceptive system function. This may further predispose an individual to increased rates of injury as compared to those who have appropriately functioning proprioceptive systems. In a study done by Sahin et al[13], researchers compared proprioception between patients with HMS and non-hypermobile individuals. Subjects with HMS had significantly higher number of errors with performing the proprioception tests as compared to non-hypermobile subjects. The study then looked at the effects of exercise and joint proprioception in those with HMS. Following a series of proprioceptive exercises, subjects showed a significant increase in proprioceptive senses. Although exercise will not reduce joint laxity, it is shown to improve function of the surrounding musculature by increasing joint proprioception. Therefore, individuals with HMS who are made aware of the condition and regularly exercise may improve their overall joint stability which could potentially decrease their risk for injury.

Individuals with hypermobility who do not take appropriate precautions have an increased risk of injury, including dislocations, subluxations, and sprains[16]. The athletic population in particular has been extensively studied regarding the relationship between HMS and injury prevalence. A recent study found that elite soccer players with HMS experienced a higher incidence of having an injury, a re-injury, or a severe injury than those without HMS[17]. Furthermore, a 2010 meta-analysis found that athletes with HMS experienced increased rates of lower extremity injuries than their non-hypermobile counterparts. Knee joint injuries in particular were more common in the hypermobile athletes. However, it was also found that there was no significant increase in ankle injuries in athletes with HMS[18]. In fact, a 2006 review established that ankle hypomobility, rather than hypermobility, may be a predictor for ankle sprains[19]. Considering that students and therapists in the physical and occupational therapy fields have high rates of athletic participation, it is important to understand the associations with increased injuries. Furthermore, as practicing professionals, PTs and OTs need to understand the existing relationship between HMS and musculoskeletal injures in order to prevent them[20].

One common location of upper extremities injuries for individuals with HMS occurs at the glenohumeral joint[21]. Multidirectional glenohumeral instability (MDI) has long been associated with hypermobility. Neer and Foster[22] found that 47% of those with MDI had generalized ligamentous laxity, while Cooper and Brems[23] noted that 76% of MDI surgical patients had generalized hypermobility. Instability in the glenohumeral joint often leads to dislocation injuries. A 2013 study which assessed the risk of recurrent shoulder dislocations in individuals with hypermobility found that the hypermobile individuals had a 60% incidence of recurrent dislocations while non-hypermobile only had 39% [24]. There are no other recent studies available at this time, which address the recurrence rates of injuries in association with hypermobility.

Long term complications are associated with HMS and may have an impact on the working physical or occupational therapist. Such chronic conditions include osteoarthritis (OA) as well as osteoporosis. It was previously believed that HMS was strongly correlated with OA, however there is now conflicting evidence regarding whether hypermobility was a risk factor or protective factor for OA. Jonsson et al[25] found that those with hypermobility were more likely to have OA of the thumb while a 2004 study found hypermobility to be a protective factor for all joints of the hand[26]. Chen et al[27] also found that there is an inverse relationship between HMS and hand and knee OA in regards to biological serum markers for OA. The risk of developing osteoporosis is increased with HMS. Gulbahar et al[28] found that hypermobility was associated with a 1.8 times increased risk for low bone mass. HMS could increase the risk of osteoporotic related injuries later in a therapist's career.

Individuals with HMS are often seen by orthopedic physicians and physical therapists for an injury or disorder without the health care provider knowing or acknowledging the underlying HMS[7]. Often times, physicians may perceive little benefit from diagnosis of HMS due to the lack of definitive pharmacological or surgical treatment. According to Adib et al[16], less than 10% of HMS cases are recognized by primary care physicians. Therefore, primary care physicians and other healthcare professionals should be aware of the clinical presentation of HMS in order to make the diagnosis and educate patients on how to prevent future injury.

Research shows that the work demands of physical therapists puts them at an increased risk for musculoskeletal injuries, and this risk increases if they also have HMS. According to Bork et al[3], 61% of physical therapists have experienced work related musculoskeletal symptoms. In this study, the area that was found to be the most commonly affected was the low back with 45% of the PT population having symptoms. Low back pain is especially common in therapists who work at a site where patients are more dependent on their therapy session such as rehabilitation facilities. The second most commonly affected area in this study was wrists and hands with 29.6% being affected in the population[3]. These injuries could occur from performing repeated manual therapy such as joint mobilizations. Therapists who have HMS may be more susceptible to pain and injuries to their wrists and hands during these techniques. In another study, it was found that therapists had a higher percentage of aggravating thumb pain when they performed increased repetitions or graded pressures during manual therapy, worked frequently with patients of similar diagnoses, or worked longer hours[29].

Measures

In 1964, Carter and Wilkinson developed the first assessment tool for systemic joint hypermobility[30]. In 1973, this assessment tool was modified by Beighton et al[9]. Knee hyperextension, elbow hyperextension, and thumb opposition measurements were continued to be used in the new modified scale. Two more measurements were added, these included hyperextension of the 5th digit and forward flexion of the trunk. With the 1998 revised Beighton Scale, individuals can score up to nine points if all measurements are positive. The nine measurements are accounted for with eight bilateral extremity measurements, and one unilateral trunk measurement. A score of four or more out of nine indicates systemic hypermobility[31]. Additional systemic hypermobility assessments include: Modified 9-point Beighton, 6-point Beighton and Horan, Modified 5-Point Carter and Wilkinson, Modified 10-Point Carter and Wilkinson, 5-Point Nicholas, and 8-

Point Wynne and Davies[18]. The Beighton Scale was used for this study because it is currently the most common one used for research[32].

CHAPTER III

METHODS

Subjects

A total of 89 participants, 25 males and 64 females between the ages of 20-37 years, voluntarily participated in this research study which was approved by University of North Dakota IRB-201202-291 (Appendix A) All involved participants were currently enrolled in either PT or OT professional curriculum. Exclusion criteria included: women who were pregnant, subjects who were under the care of physician in regards to a musculoskeletal injury, or subjects who had a known connective tissue disorder. Two female participants were excluded from participating in hypermobility measurements as they were being seen by a physician for a musculoskeletal injury. One male participant was considered an outlier due to excessive injury rates and was not included in the statistical analysis. The final subject inclusion was n=86 (male=24, female=62). See Table 1 for more demographic information for the participants.

Instrumentation

The Beighton Hypermobility Scale was utilized to assess systemic hypermobility in all participants. This scale measures hyperextension of the elbow, 5th metacarpal phalangeal joint, and knee through goniometric measurements, as well as measures ability to achieve passive thumb apposition to forearm and forward trunk flexion (see Figures 1-5).

Table 1: Demographics of participants

Characteristic	Mean	Range
Age (years)	23	20-37
Height (inches)	67.1	60-74
Weight (pounds)	150.4	110-235
Physical Activity (days/week)	3.7	0-7
Characteristic	**N**	**Percentage**
Gender Female Male	 N=62 N=24	 72.1% 27.9%
Hand Dominance Left Right	 N=9 N=77	 10.5% 89.5%

Instrumentation

The Beighton Hypermobility Scale was utilized to assess systemic hypermobility in all participants. This scale measures hyperextension of the elbow, 5th metacarpal phalangeal joint, and knee through goniometric measurements, as well as measures ability to achieve passive thumb apposition to forearm and forward trunk flexion. (See Figures 1-5)

Goniometric measurements for the knee and elbow were assessed using a 12 inch 360 degree goniometer with 1 degree increments. Fifth digit hypermobility was assessed using a 6 inch 180 degree goniometer with 2 degree increments. The same goniometers were used throughout the entire study to reduce measurement error.

Intra-rater reliability was established prior to data collection to confirm goniometric consistency within each researcher. According to Portney and Watkins[33], "poor to moderate" reliability is defined as having an interclass correlation coefficient of below .75, while above .75 is considered "good". To ensure reasonable reliability, .90 is recommended for clinical measurements. Following the reliability study, one researcher had reliability of .942 for the 5th digit extension. A second researcher had a reliability of .961 for elbow extension. A third researcher had a reliability of .966 for knee extension. The researchers with the highest intra-rater reliability measured that specific joint throughout the entire study for all subjects.

Procedure

Subjects first read and signed an informed consent form. (Appendix B) Each subject completed a survey pertaining to demographic data, activity and injury history (Appendix C), and was informed that they could bypass any questions that they did not wish to answer. Any subjects who met exclusion criteria did not participate in the study.

Following completion of the survey, researchers completed the Beighton Hypermobility Assessment with each participant (Table 2). The measurements were taken in a private room to ensure subject confidentiality. The order of joint measurements was 5th metacarpal extension, thumb apposition, elbow extension, knee extension, and lastly trunk-flexion. Limb measurements were performed on the right side first. The participants received a score from zero to nine. A point was received for each measurement that was deemed hypermobile (Table 1). If the subject scored a 4 or higher, they were considered hypermobile[31].

All measurements were recorded on the data collection form. (Appendix D) The elbow, knee, and 5th digit were recorded to the nearest 1°. Trunk flexion and apposition of the thumb was recorded as a yes if they were able to complete the test, and no if they were unable. The data collection form did not contain any identifiable information other than the identification number that correlated with the survey.

Data Analysis

Data extracted from the survey by the 4 authors included participants age, gender, height, hand dominance, weight, inclusion criteria (not pregnant or nursing, care of physician for a musculoskeletal injury, or connective tissue disorder), athletics/sports participation, physical activity level, injury history, injury mechanism, medical attention for injury, received PT or OT, required surgery, and had any lasting disability. Data was recorded and organized using IBM SPSS statistics 21.0[34]. Pearson chi-square statistical analysis was used to determine if there was a significant relationship between hypermobility and the type or number of injuries. The statistical significance was set at $\alpha=0.05$.

Table 2: Beighton Scale Measurements

Measurements	Position	Directions	Goniometer alignment	Point Gained
Elbow extension	Supine with shoulder in 15° abduction, 0° flexion, neutral rotation, and wrist fully supinated	Subject was relaxed with proximal to the olecranon on 12 inch towel roll	**Axis:** Lateral epicondyle **Stationary arm:** Acromion **Movable arm:** Radial head and styloid process	10° or more of hyperextension, one point for each side
Fifth metacarpal extension	Sitting with shoulder at 90° flexion, elbow & wrist in neutral	Subject pulled proximal phalanx into extension until feeling a stretch that was slightly uncomfortable without producing pain	**Axis:** 5th MCP joint **Stationary arm:** 5th metacarpal **Movable arm:** 5th proximal phalanx	90° or more of extension, one point for each side
Knee extension	Supine with neutral hip rotation	Subject was relaxed with heel on 32 inch pillow roll	**Axis:** Joint line **Stationary arm:** Lateral epicondyle and greater trochanter **Movable arm:** Fibular head and lateral malleolus	10° or more of hyperextension, one point for each side
Thumb apposition	Sitting	Examiner first demonstrated, then performed passively by subject	N/A	Able to oppose thumb to forearm, one point for each side
Trunk-flexion test	Standing with feet shoulder width apart and knees extended	Examiner first demonstrated, then completed by subject	N/A	Could touch their palms flat to the floor

Figure 1: Measurement of elbow hyperextension greater than 10°

Figure 2: Measurement of 5th digit extension greater than 90°

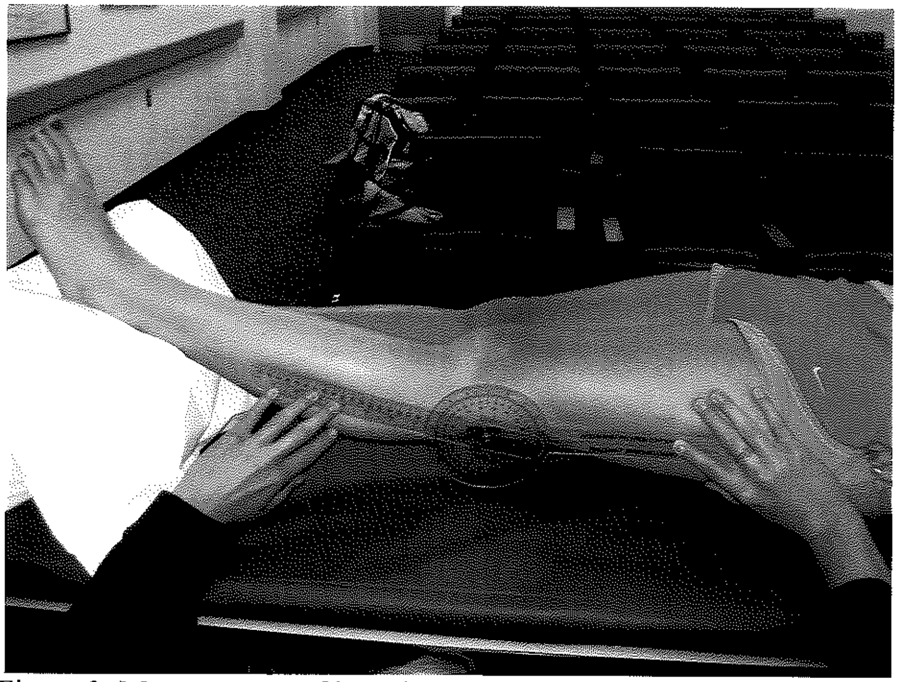

Figure 3: Measurement of knee hyperextension greater than 10°

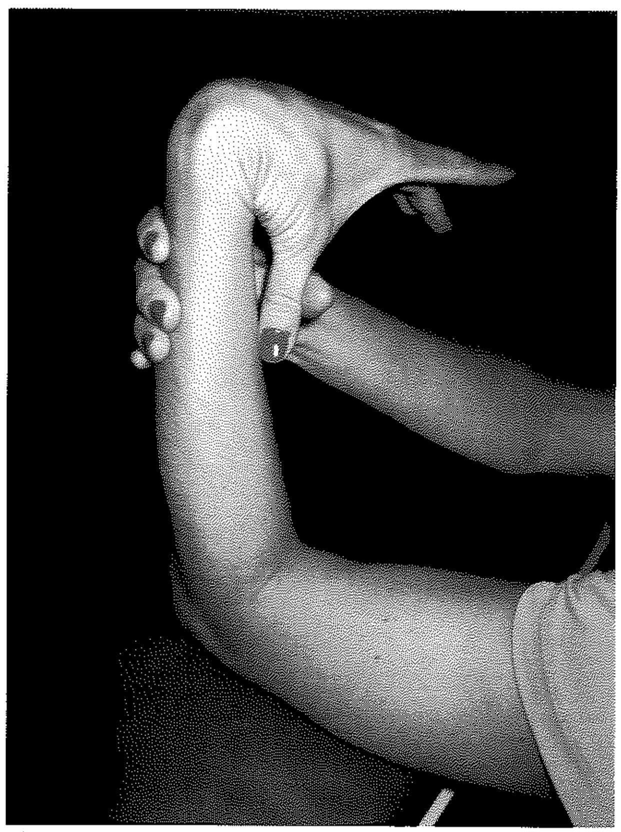

Figure 4: Apposition of the thumb to forearm

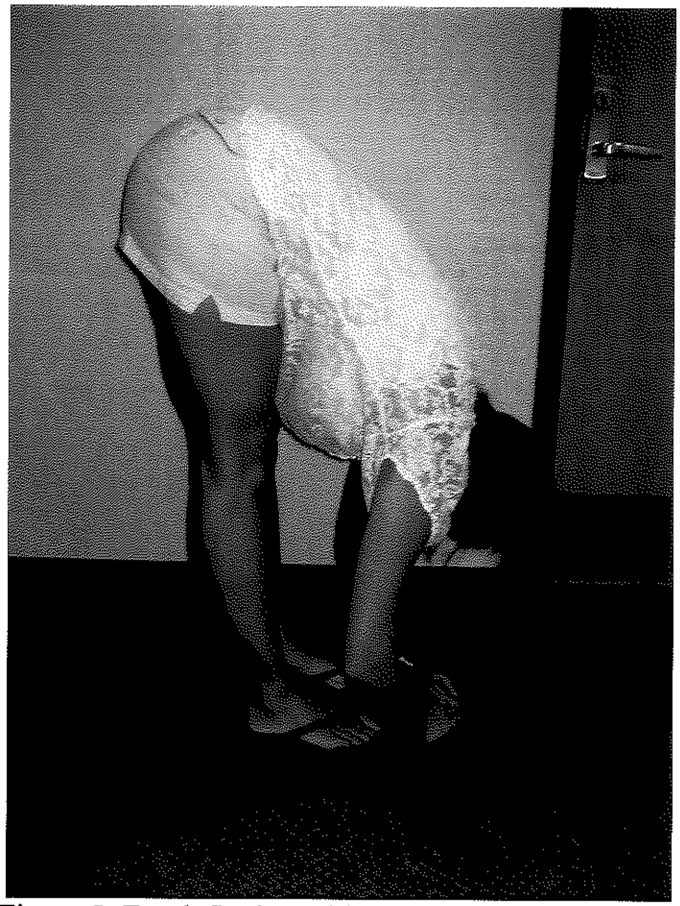

Figure 5: Trunk flexion with palms flat on floor

CHAPTER IV

RESULTS

Eighty-nine PT and OT students (25 male, 64 female) voluntarily participated in this research study, three of which were excluded (1 male and 2 females). Of these 86, there were 54 PT participants and 32 OT participants. The prevalence of hypermobility was found to be 39.5% (n=34) overall in the subject population, with a prevalence of 33.3% and 50% in PT and OT student participants, respectively. Of the 34 students with hypermobility, 25 (71.4%) were female and 9 (26.5%) were male.

The questionnaire revealed that a majority of participants were active with a mean of 3.7 ± 2.08 days per week of exercise participation. All of the subjects reported that they participated in at least one athletic activity during either pre-high school, high school, college, intramural, or non-organized (independent) athletics. The most commonly listed athletic activities which subjects participated in were basketball (49 subjects), volleyball (41), track and field (38), softball (23), and soccer (22).

The injuries reported on the questionnaire included: sprains, strains/contusion, dislocation, fractures, ligament ruptures, and "other injuries". There was a statistically significant difference in strain/contusion injuries between non-hypermobile and hypermobile individuals with non-hypermobile participants being twice as likely to have had a strain type injury compared to those who were hypermobile χ^2 (1, n=86)=5.06, p=0.024 (see Table 2 and Figure 6). There was no statistical significance between groups regarding the number of sprains, ligament ruptures, fractures, and dislocations (see Table

3). Though there was no statistical significance, fractures were reported more frequently in individuals who were non-hypermobile than those who were hypermobile with 44.2% and 29.4% having a fracture respectively.

Table 3: Injury type reported by participants

Type of Injury	Hypermobile (N=35)	Non-hypermobile (N=52)	χ^2	p value
Sprain	70.6% (n=33)	63.5% (n=24)	0.467	0.494
Ligament rupture	8.8% (n=3)	5.8% (n=3)	0.296	0.587
Strain/Contusion	20.6% (n=7)	44.2% (n=23)	5.059	0.024
Fracture	29.4% (n=10)	44.2% (n=23)	1.909	0.167
Dislocation	29.4% (n=10)	21.2% (n=11)	0.760	0.383

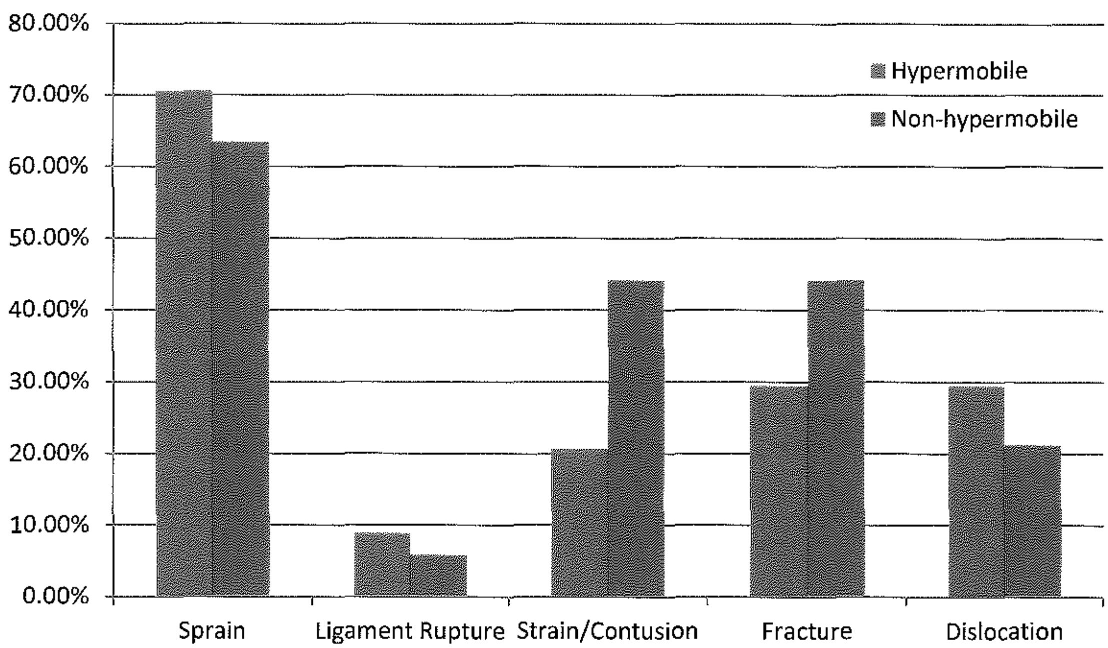

Figure 6: The percentage of participants in each group that have experienced at least one of the respective injuries.

CHAPTER V

DISCUSSION AND CONCLUSION

Discussion

The results showed that 39.5% of PT and OT students presented with hypermobility, and there was no significant difference in hypermobility rates between PT and OT students. This rate is greater than five times the rate of hypermobility found in the general population, which is 7.6%[8]. Our findings also support the literature that females have a higher prevalence of hypermobility than males. In this study, of the 34 students with hypermobility, 25 (73.5%) were female and 9 (26.4%) were male.

Literature has shown that hypermobility increases musculoskeletal symptoms and injuries; however our results did not support these findings[17]. While the overall reported number of injuries in those with hypermobility was elevated, it was not significantly different from those without hypermobility. Strains were the only injury that was significantly associated with hypermobility status, specifically that they were increased in the non-hypermobile participants. Fractures were more common in the non-hypermobile population while dislocations, sprains, and ligament ruptures were reported more often in the hypermobile population. Although not significant, there was a trend that intra-articular injuries, which included sprains, ligament ruptures, and dislocations were more common in individuals with HMS (see Figure 6). The reason for this could be that when joints are hypermobile, they could have increased instability due to the laxity[20]. This possible instability could be why intra-articular injuries were found to be more prevalent in the hypermobile group.

Throughout the data collection process several subjects indicated that their past participation in various activities such as gymnastics, cheerleading, and dance which require significant flexibility, likely contributed to their hypermobility status. From the information collected on the questionnaires, 6 out of 8 dancers and 5 out of 9 gymnasts were found to be hypermobile. This finding agrees with research that these athletes tend to have a higher prevalence of hypermobility. Further research needs to be performed to determine if hypermobility in dancers and gymnasts is due to genetics or lifestyle.

The increased number of injuries reported by the participants may be related to the increased activity levels of the entire subject population. There was not a significant difference between activity levels between the hypermobile and non-hypermobile individuals. Both groups indicated that they were active in sport participation when they were younger, and currently there was a median of 4 days of exercise per week. Because both populations are equally active, they are both at a high risk of injuries, making it difficult to detect differences in injury rates associate with hypermobility.

It has been found that individuals with HMS have a significant decrease in proprioceptive feedback. This could lead to an increased risk of injury. However, someone with HMS can improve his or her proprioceptive senses with proprioception exercise training[13]. No proprioceptive testing was performed in this study so it is unknown if there is a difference in proprioception between participants with and without HMS. However, the majority of participants in this study indicated that they have been active in sports throughout their lives. Therefore, participants with HMS could potentially have comparable proprioceptive feedback to participants who are non-hypermobile if regular exercise in general could be shown to have an impact on improving proprioception. This may account for the lack of difference in injury rates among the two populations. Future studies would need to be conducted in order to confirm this possibility.

There is conflicting research regarding how HMS may contribute to future disease processes such as osteoarthritis. However, it has been shown that the risk of developing other diseases, such as osteoporosis, is increased in individuals who have HMS. Therefore, it is important that participants who were found to have HMS be educated on potential future risks in order to take preventative measures.

The results of this study did not confirm findings of previous studies that showed an increased prevalence of injuries in subjects with HMS. Flaws within the survey, specifically questions regarding the recurrence of joints injured did not allow analysis of injury recurrence rates. There is currently minimal research on injury recurrence rates and hypermobility status. It remains necessary that future studies continue to pursue this topic.

Limitations of the Study

The sample size for this study was larger than other studies, but still quite small. Intentions were to pool the data with those from previous studies, however, modifications to the data intake form prevented data pooling. Future studies should be able to utilize the data from this study to create a larger sample size. The sample size was also limited because only PT and OT students attending the University of North Dakota during spring and summer semesters were included as participants.

Although the data form was improved from the study two years ago to include more information on number of injuries experienced, a majority of participants found it to be difficult to understand. Therefore, some data was inconsistent. It was also difficult for participants to recall their past injuries and the age of occurrence. Participants were instructed to recall their injury history to the best of their ability, so there was subjectivity in the provided data. For future studies, the survey should be modified to ensure that all injuries are accounted for in terms of injury type and mode of injury.

Improvements to this study could include a more detailed data analysis to reveal if there is a relationship between hypermobility of a particular joint and injury occurrence of that joint. It is also recommended that future studies look at mechanism of injuries compared to hypermobility status. The current study had too small of a sample size to be able to analyze this data.

Conclusion

This research study investigated the prevalence of systemic hypermobility among PT and OT students as well as the correlation with previous injury history. There was a significant finding that non-hypermobile participants were more likely to experience a strain that those with HMS. Although not significant, trends in the data demonstrated that non-hypermobile group had a greater rate of fractures while the participants with HMS had a greater prevalence of sprains, ligament ruptures, and dislocations. This study found that PT and OT students have a higher prevalence of HMS compared to the general population[8]. Therefore, it is important for PTs and OTs to be aware of their hypermobility status and the associated injury risks when working with patients. Extra precautions should be taken by both physical and occupational therapists who have HMS to prevent injuries[29].

APPENDIX A

REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW
University of North Dakota Institutional Review Board

Date: 2/16/2012 **Project Number:** IRB-201202-291

Principal Investigator: Jeno, Susan

Department: Physical Therapy

Project Title: Association of Generalized Joint Hypermobility and Occurrence of Musculoskeletal Injury Among Physical and Occupational Therapy Students

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on February 24 2012 and the following action was taken:

[X] Project approved. **Expedited Review** Category No. 4 and 7
Next scheduled review must be before: February 23, 2013

[X] **Copies of the attached consent form with the IRB approval stamp dated** February 24, 2012 **must be used in obtaining consent for this study.**

[ ] Project approved. **Exempt Review** Category No. ______
This approval is valid until ______ as long as approved procedures are followed. No periodic review scheduled unless so stated in the Remarks Section.

[ ] **Copies of the attached consent form with the IRB approval stamp dated ______ must be used in obtaining consent for this study.**

[ ] Minor modifications required. The required corrections/additions must be submitted to RDC for review and approval. **This study may NOT be started UNTIL final IRB approval has been received.**

[ ] Project approval **deferred. This study may not be started until final IRB approval has been received.** (See Remarks Section for further information.)

[ ] Disapproved claim of exemption. This project requires Expedited or Full Board review. The Human Subjects Review Form must be filled out and submitted to the IRB for review.

[ ] Proposed project is not human subject research and does not require IRB review.
[ ] Not Research [ ] Not Human Subject

PLEASE NOTE: **Requested revisions for student proposals MUST include adviser's signature. All revisions MUST be highlighted.**

[X] Education Requirements Completed. (Project cannot be started until IRB education requirements are met.)

cc: Chair, Physical Therapy

[signature] February 24, 2012
Signature of Designated IRB Member — Date
UND's Institutional Review Board

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 310 Form may be required. Contact RDC to obtain the required documents.

(Revised 10/2006)

APPENDIX B

INFORMED CONSENT

TITLE:	*Association of Generalized Joint Hypermobility and Occurrence of Musculoskeletal Injury in Physical and Occupational Therapy Students*
PROJECT DIRECTOR:	*Susan H N Jeno, PT, PhD*
PHONE #	*777-2831*
DEPARTMENT:	*Physical Therapy*

STATEMENT OF RESEARCH

A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only subjects who choose to take part. Please take your time in making your decision as to whether to participate. If you have questions at any time, please ask.

You are invited to be in a research study comparing generalized joint hypermobility and injury rates because you are a student in the professional program of either Physical or Occupational Therapy at the University of North Dakota.

The purpose of this study is to determine if individuals identified with generalized joint hypermobility (excessive joint mobility) are at a higher risk of incurring musculoskeletal injury. The findings of this study will help determine if preventative steps need to be taken to prevent injury in individuals with hypermobility during the academic preparation and future professional practice. You will be made aware if you are identified as being hypermobile. Results of the study will be available to you to assess the need of a preventative program. Approximately 200 people will take part in this study at the University of North Dakota. Your participation in the study will last approximately 20 minutes. You will need to visit the Department of Physical Therapy one time.

WHAT WILL HAPPEN DURING THIS STUDY?

Each subject will be asked to complete a questionnaire pertaining to demographic data, activity, and injury history. The subject is free to skip any questions that he/she would prefer not to answer. The Beighton method of testing joint laxity and criteria will be used to as the measure of generalized joint hypermobility. Subjects will be assessed on their ability to do the following tests: Hyperextend the little finger beyond 90 degrees, hyperextend the elbows beyond 10 degrees, hyperextend the knees beyond 10 degrees, apposition of the thumb to the flexor aspect of the forearm, and forward flex the trunk so the palms easily touch the floor with the knees fully extended. A scoring system of zero to nine is utilized with one point given for each extremity bilaterally and one point for the trunk if the test is positive for the aforementioned criteria. A subject with a score of 4 or more will be considered hypermobile. It is expected that the entire procedure will take approximately 20 minutes to complete.

Approval Date: 30
Expiration Date: 9
University of North Dakota IRB

Date______
Subject Initials: ______

WHAT ARE THE RISKS OF THE STUDY?

There may be some risk from being in this study, though the risks to the subjects are anticipated to be minimal and unlikely in this study. The only risk the subject may experience is a momentary slight discomfort if excessive force is used to move their joint into position for the tests. The subjects will be asked to move their joints only within their available range. If injury should occur, medical treatment will be available, including first aid, emergency treatment, and follow-up care as it is to a member of the general public in similar situations. payment for such treatment must be provided by the subject and their third party payer, if any.

WHAT ARE THE BENEFITS OF THIS STUDY?

By assessing if individuals with generalized joint hypermobility are at a greater risk of injury during normal daily activities compared to individuals who are not hypermobile, therapeutic methods can be developed to prevent injury. With this knowledge, hypermobile individuals may be able to avoid injury. The subjects in this study will be made aware if they have generalized joint hypermobility or not. Following the study, the results will be made available to the subjects to allow them to assess whether a preventative program would be beneficial to them. The findings of this study will be directly applicable to injury prediction and the need for preventative intervention. To society as a whole, recognition of injury rates and taking preventative measures to limit the those injuries will help to control health care costs for the professionals and hopefully help them lead longer, injury free careers. You will not have any costs for being in this research study nor will you will not be paid for being in this research study.

WHO IS FUNDING THE STUDY?

The University of North Dakota and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

CONFIDENTIALITY

The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, you will not be identified. Your study record may be reviewed by persons that audit IRB procedures at the University of North Dakota. Any information that is obtained in this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained as each participant will be assigned a randomly selected identification number at the beginning of the study, which will be known by the researchers only. All information involving the research study will be secured in a locked cabinet inside the Department of Physical Therapy at the University of North Dakota. A hard copy of the statistically analyzed data along with the data collection sheets from the study will be secured in a locked cabinet inside the Department of Physical Therapy located at the University of North Dakota. Unless the data is required for future studies, the information will be destroyed via shredding three years after the study has been completed.

If we write a report or article about this study, we will describe the study results in a summarized manner so that you cannot be identified.

Approval Date: 30
Expiration Date: 9
University of North Dakota IRB

Date________
Subject Initials: ________

COMPENSATION FOR INJURY
In the event that this research activity results in an injury, treatment will be available including first aid, emergency treatment and follow-up care as needed. Payment for any such treatment is to be provided by you (you will be billed) or your third-party payer, if any (such as health insurance, Medicare, etc.) No funds have been set aside to compensate you in the event of injury. Also, the study staff cannot be responsible if you knowingly and willingly disregard the directions they give you.

IS THIS STUDY VOLUNTARY?
Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota.

CONTACTS AND QUESTIONS?
The researchers conducting this study are Susan H. N. Jeno, PT, PhD and Year 2 Graduate Physical Therapy Students. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research please contact Susan Jeno at 777-2831 during the day. If you have questions regarding your rights as a research subject, or if you have any concerns or complaints about the research, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279. Please call this number if you cannot reach research staff, or you wish to talk with someone else.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subjects Name: ______________________________

______________________ ______________
Signature of Subject Date

Approval Date: 30
Expiration Date: 9
University of North Dakota IRB

3

Date________
Subject Initials:________

APPENDIX C

ID # 90

Participant Survey

Age: ____________ Height (in ft. and in.): ____________

Gender: M F Dominant hand: L R Weight in pounds: ______________

If female, are you pregnant or nursing? Yes No

Are you currently under the care of a physician for a musculoskeletal injury? Yes No

Do you have a diagnosed connective tissue disorder? Yes No

Athletic Activity

Did/do you compete in (Circle all that apply): pre-high school, high school, college, intramural, or non-organized (independent) athletics?

If yes, list sport(s)____

____

How many days/week do you currently participate in athletic activities during an average week?
0 1 2 3 4 5 6 7

What type of physical activity do you participate in? List all that apply__________________

____

Injury History

The remaining questions concern your injury history. Please complete the following charts and questions so that we can gain an understanding of the types and numbers of injuries you may have sustained in the past.

Place indicate your **age** at time of injury in the appropriate box to indicate the type of injury you have sustained, if more than one injury, please indicate the **number** (ie. 2 left ankle sprains age 16 and 18).

Sprain			**Strain/contusion**			**Fracture**			**Dislocation**		
Joint	Right	Left	**Muscle**	Right	Left	**Bone**	Right	Left	**Bone**	Right	Left
Toes			Foot			Toes			Toes		
Ankle			Anterior leg			Metatarsal			Metatarsal		
Knee			Posterior leg			Tarsal			Tarsal		
Hip			Quadriceps			Tibia			Tibia		
Back/Neck			Hamstrings			Fibula			Fibula		
Shoulder			Hip Adductors			Patella			Patella		
AC/SC			Hip Flexors			Femur			Femur		
Elbow			Gluteals			Pelvis			Pelvis		
Wrist			Low back			Vertebrae			Spine		
Fingers			Mid back			Rib			Rib		
Thumb			Neck			Clavicle			Clavicle		
Other			Abdominals			Scapula			Scapula		
			Anterior Chest			Humerus			Humerus		
Ligament Rupture			Biceps			Radius			Radius		
ACL			Triceps			Ulna			Ulna		
PCL			Wrist flexors			Carpal			Carpal		
MCL			Wrist extensors			Metacarpal			Metacarpal		
LCL			Finger flexors			Finger			Finger		
ATF			Other hand muscles			Thumb			Thumb		
Other			Thumb muscles			Skull			Skull		
						Jaw			Jaw		

Other (Please specify and include age you were when you were injured):

Of your listed injuries, please indicate how many injuries were due to:							
Condition	**Sprain**	**Strain**	**Contusion**	**Fracture**	**Dislocation**	**Concussion**	**Other**
Overuse							
Trauma							
Other							
If known, please indicate what activity caused each injury listed above, choose 1 option for each injury.							
Sport Performance							
Work							
General Activity							
Other							

Please indicate which, if any, injuries for which you sought medical attention.

Please indicate which, if any, injuries for which you received Physical or Occupational Therapy.

Please indicate which, if any, injuries required surgery.

Please indicate which, if any, injuries resulted in lasting disability.

Thank you for your time with this research study.

APPENDIX D

ID # 90

DATA COLLECTION FORM

JOINT TESTED		YES	NO
5^Th FINGER	LEFT		
	RIGHT		
THUMB	LEFT		
	RIGHT		
ELBOW	LEFT		
	RIGHT		
KNEE	LEFT		
	RIGHT		
TRUNK			
TOTAL SCORE			

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